IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	M. Masters et al.
Serial No.:	09/944,315
For:	Textured Surfaces for Hearing Instruments
Filed:	August 31, 2001
Group:	2643
Examiner:	Phylesha L. Dabney
Att'y Dkt.:	2001 P 16281 US

Certificate of Transmission
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I hereby certify that this paper is being sent this day via facsimile to 703-872-9315.

Joel Miller
Attorney Name

29,955
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Signature

March 2, 2004
Date of Signature

Certification of Martin Masters under 37 C.F.R. § 1.132

I, Martin W. Masters, declare: Via Facsimile Only

1. I am one of the applicants of the above identified patent application.

2. I have read the section of the office action mailed January 2, 2004 titled "Response to Arguments," where a section of the application is quoted as a rationale for construing the claims to encompass the cited reference, U.S. Patent No. 6,401,859 (Widmer et al.), and I have reviewed the cited reference. None of the structures disclosed in the cited reference illustrate or suggest a textured surface.

3. I disagree with the construction urged in the office action as it is contrary to the usage of the term texture in the application and the usage of the term by those skilled in the art.

4. In the application, texture is defined in part on page 2, lines 8-13, as follows:

> By creating a textured, non-smooth finish on the outer shell of a hearing instrument, the hearing instrument will more readily lodge and remain within the ear canal. Further, the textured finish has an appearance closer to that of natural skin and therefore the hearing instrument is less noticeable to others, blending in with the visible portions of the ear.

5. To further illustrate the meaning of the term texture, I provided my attorneys with an excerpt from one of my reference books, titled "Surface-Texture Designation, Production, and Control," Marks' Standard Handbook for Mechanical Engineers, 9th ed., 1987, pages 13-75 through 13-81, referenced in the application on page 5. This is consistent with my understanding and usage of the term "texture." Copy attached.

6. I certify under penalty of perjury that the foregoing is true and correct.

Executed on March 1, 2004.

Martin W. Masters
Martin W. Masters

Marks'

Standard Handbook for Mechanical Engineers

Revised by a staff of specialists

EUGENE A. AVALLONE *Editor*

Consulting Engineer; Professor Emeritus of Mechanical Engineering,
The City College of the City University of New York

THEODORE BAUMEISTER III *Editor*

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0.13 mm). The tool material is normally cold-rolled steel or stainless steel and is brazed, soldered, or fastened mechanically to the transducer through a toolholder. The tool is ordinarily 0.003 to 0.004 in (0.075 to 0.1 mm) smaller than the cavity it produces. Tolerances of 0.0005 in (0.013 mm) or better can be obtained with fine abrasives. For best results, roughing cuts should be followed with one or more finishing operations with finer grits. The ultrasonic machining process is used in drilling holes, engraving, cavity sinking, slicing, broaching, etc. It is best suited to materials which are hard and brittle, such as ceramics, carbides, borides, ferrites, glass, precious stones, and hardened steels.

In **abrasive-jet machining (AJM)**, material is removed by fine abrasive particles (aluminum oxide or silicon carbide) carried in a high-velocity stream of air, nitrogen, or carbon dioxide. The gas pressure ranges up to 120 lb/in^2 (0.83 MPa), providing a nozzle velocity of up to 1,000 ft/s (300 m/s). Nozzles are made of tungsten carbide or sapphire. Typical applications are in drilling, sawing, slotting, and deburring of hard, brittle materials such as glass

In **laser-beam machining (LBM)**, material is removed by converting electric energy into a single-wavelength, narrow beam of light and focusing it on the workpiece. The high energy density of the beam is capable of melting and vaporizing all materials. Typical applications are in drilling small holes in all types of materials, as small as 0.0002 in (0.005 mm) in diameter, and cutting titanium and nonmetallic materials such as fabric, wood, cardboard, and plastics. It is desirable for the workpiece material to have low thermal conductivity and low reflectivity.

The **electron-beam machining (EBM)** process removes material by focusing high-velocity electrons on the workpiece. Unlike lasers, this process is carried out in a vacuum chamber and is used for drilling small holes in all materials including ceramics, scribing, and cutting slots.

In **water jet machining**, water is ejected from a nozzle at pressures as high as 200,000 lb/in^2 (1,400 MPa) and acts like a saw. The process is suitable for cutting and deburring of a variety of materials such as polymers, paper, and brick in thicknesses ranging from 0.03 to 1 in (0.8 to 25 mm) or more. The cut can be started at any location, wetting is minimal, and no deformation of the rest of the piece takes place. Abrasives can be added to the water stream to increase material removal rate.

13.5 SURFACE-TEXTURE DESIGNATION, PRODUCTION, AND CONTROL

by James A. Broadston

REFERENCES: American National Standards Institute, "Surface Texture," ANSI B46.1. Broadston, "Control of Surface Quality," Surface Checking Gage Co., Hollywood, CA, 1977. ASME "Metals Engineering Design Handbook," McGraw-Hill. SME "Tool Engineers Handbook," McGraw-Hill.

Rapid changes in the complexity and precision requirements of mechanical products since 1945 have created a need for improved methods of determining, designating, producing, and controlling the surface texture of manufactured parts. Although standards are aimed at standardizing methods for measuring by using stylus probes and electronic transducers for surface quality control, other descriptive specifications are sometimes required, i.e., interferometric light bands, peak-to-valley by optical sectioning, light reflectance by commercial glossmeters, etc. Other parameters are used by highly industrialized foreign countries to solve their surface specification problems. These include the high spot counter and bearing area meter of England (Talysurf); the total peak-to-valley, or R_t, of Germany (Perthen); and the R or average amplitude of surface deviations of France. In the United States peak counting is used in the sheet-steel industry, instrumentation is available (Bendix), and a standard for specification, SAE J-911, exists.

Surface texture control should be considered for many reasons, among them being the following:

1. Advancements in the technology of metal-cutting tools and machinery have made the production of higher-quality surfaces possible.
2. Products are now being designed that depend upon proper quality control of critical surfaces for their successful operation as well as for long, trouble-free performance in service.
3. Craftsmen who knew the function and finish requirements for all the parts they made are gradually being replaced by machine operators who are not qualified to determine the proper texture requirements for critical surfaces.
4. Remote manufacture and the necessity for controlling costs have made it preferable that finish requirements for all the critical surfaces of a part be specified on the drawing.
5. The design engineer, who best understands the overall function of a part and all its surfaces, should be able to determine the requirement for surface-texture control where applicable and to use a satisfactory standardized method for providing this information on the drawing for use by manufacturing departments.
6. Manufacturing personnel should know what processes are able to produce surfaces within specifications and should be able to verify that the production techniques in use are under control.
7. Quality-control personnel should be able to check conformance if product quality is to be maintained and product performance and reputation ensured.
8. Test personnel should be able to operate completed products, as well as detail components, under simulated environmental conditions to determine shortcomings in design that may prevent satisfactory and trouble-free performance of the product in service.
9. The design engineer should be fully cognizant of product performance and/or failure and of the reasons therefor, both

in test and during customer operation, and should be able to apply such information toward the improvement of future designs.

10. Too much control may be worse than too little; hence, overuse of available techniques may hinder rather than assist, there being no payoff in producing surfaces that are more expensive than required to ensure product performance to established standards.

DESIGN CRITERIA

Surfaces produced by various processes exhibit distinct differences in texture. These differences make it possible for honed, lapped, polished, turned, milled, or ground surfaces to be easily identified. As a result of its unique character, the surface texture produced by any given process can be readily compared with other surfaces produced by the same process through the simple means of comparing the average size of its irregularities, using applicable standards and modern measurement methods. It is then possible to predict and control its performance with considerable certainty by limiting the range of the average size of its characteristic surface irregularities. Surface-texture standards make this control possible.

Variations in the texture of a critical surface of a part influence its ability to resist wear and fatigue; to assist or destroy effective lubrication; to increase or decrease its friction and/or abrasive action on other parts, and to resist corrosion, as well as affect many other properties that may be critical under certain conditions.

Clay has shown that the load-carrying capacity of nitrided shafts of varying degrees of roughness, all running at 1,500 r/min in diamond-turned lead-bronze bushings finished to 20 μin, (0.50 μm), varies as shown in Fig. 13.5.1 The effects of

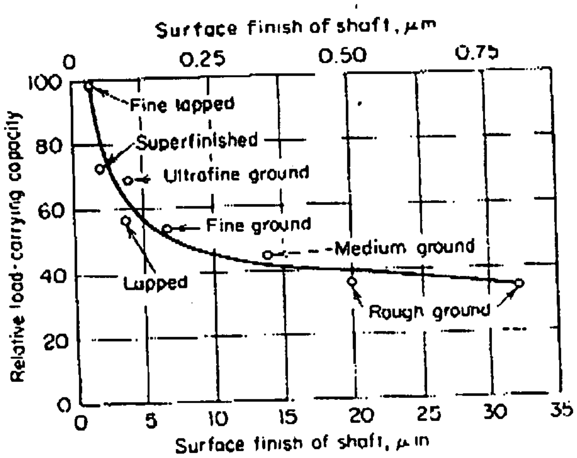


Fig. 13.5.1 Load-carrying capacity of journal bearings related to the surface roughness of a shaft. *(Clay, ASM Metal Progress, Aug 15, 1955.)*

roughness values on the friction between a flat slider on a well-lubricated rotating disk are shown in Fig. 13.5.2.

Surface-texture control should be a normal design consideration under the following conditions:

1. For those parts whose roughness must be held within closely controlled limits for optimum performance. In such cases, even the process may have to be specified. Automobile-engine cylinder walls, which should be finished to about 13 μin (0.32 μm) and have a circumferential (ground) or an angular (honed) lay, are an example. If too rough, excessive wear occurs; if too smooth, piston rings will not seat properly, lubrication is poor, and surfaces will seize or gall.

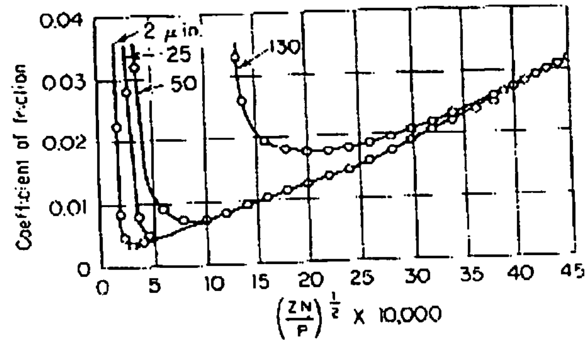


Fig. 13.5.2 Effect of surface texture on friction with hydrodynamic lubrication using a flat slider on a rotating disk. Z = oil viscosity, cP; N = rubbing speed, ft/min; P = load, lb/in^2.

2. Some parts, such as antifriction bearings, cannot be made too smooth for their function. In these cases, the designer must optimize the trade-off between the added costs of production and the market value of the added performance.

3. There are some parts where surfaces must be made as smooth as possible for optimum performance regardless of cost, such as gages, gage blocks, lenses, and carbon pressure seals.

4. In some cases, the nature of the most satisfactory finishing process may dictate the surface-texture requirements to attain production efficiency, uniformity, and control even though the individual performance of the part itself may not be dependent on the quality of the controlled surface. Hardened steel bushings, for example, which must be ground to close tolerance for press fit into housings, could have outside surfaces well beyond the roughness range specified and still perform their function satisfactorily.

5. For parts which the shop, with unjustified pride, has traditionally finished to greater perfection than is necessary, the use of proper surface-texture designations will encourage rougher surfaces on exterior and other surfaces that do not need to be finely finished.

It is the designer's responsibility to decide which surfaces of a given part are critical to its design function and which are not. This decision should be based upon a full knowledge of the part's function as well as of the performance of various surface textures that might be specified. From both a design and an economic standpoint, it may be just as unsound to specify too smooth a surface as to make it too rough—or to control it at all if not necessary. Wherever normal shop practice will produce acceptable surfaces, as in drilling, tapping, and threading, or in keyways, slots, and other purely functional surfaces, unnecessary surface-texture control will add costs which should be avoided.

Whereas each specialized field of endeavor has its own traditional criteria for determining which surface finishes are optimum for adequate performance, Table 13.5.1 provides some common examples for design review, and Table 13.5.6 provides data on the surface-texture ranges that can be obtained from normal production processes.

Table 13.5.1 Typical Surface-Texture Design Requirements

(250 μin.)	6.3	Clearance surfaces Rough machine parts
(125 μin.)	3.2	Mating surfaces (static) Chased and cut threads Clutch-disk faces Surfaces for soft gaskets
(63 μin.)	1.60	Piston-pin bores Brake drums Cylinder block, top Gear locating faces Gear shafts and bores Ratchet and pawl teeth Milled threads Rolling surfaces Gearbox faces Piston crowns Turbine-blade dovetails
(32 μin.)	0.80	Broached holes Bronze journal bearings
		Gear teeth Slideways and gibs Press-fit parts Piston-rod bushings Antifriction-bearing seats Sealing surfaces for hydraulic tube fittings
(16 μin.)	0.40	Motor shafts Gear teeth (heavy loads) Spline shafts O-ring grooves (static) Antifriction-bearing bores and faces Camshaft lobes Compressor-blade airfoils Journals for elastomer lip seals
(13 μin.)	0.32	Engine cylinder bores Piston outside diameters Crankshaft bearings
(8 μin.)	0.20	Jet-engine stator blades Valve-tappet cam faces Hydraulic-cylinder bores Lapped antifriction bearings
(4 μin.)	0.10	Ball-bearing races Piston pins Hydraulic piston rods Carbon-seal mating surfaces
(2 μin.)	0.050	Shop-gage faces Comparator anvils
(1 μin.)	0.025	Bearing balls Gages and mirrors Micrometer anvils

DESIGNATION STANDARDS, SYMBOLS, AND CONVENTIONS

The precise definition and measurement of surface-texture irregularities of machined surfaces are almost impossible because the irregularities are very complex in shape and character and, being so small, do not lend themselves to direct measurement. Although both their shape and length may affect their properties, control of their average height and direction usually provides sufficient control of their performance. The standards do not specify the surface texture suitable for any particular application, nor the means by which it may be produced or measured. Neither are the standards concerned with other surface qualities such as appearance, luster, color, hardness, microstructure, or corrosion and wear resistance, any of which may be a governing design consideration.

The standards provide definitions of the terms used in delineating critical surface-texture qualities and a series of symbols and conventions suitable for their designation and control. The ANSI B46.1 used in this section has replaced all other domestic standards and conforms in all essential elements with the British, Canadian, and most ISO international standards, even though different terms are used; i.e., the R_a, the AA (arithmetical average), and the CLA (centerline average) are identical with the internationally adopted symbol R_a of ISO R468.

The basic ANSI symbol for designating surface texture is the checkmark with horizontal extension shown in Fig. 13.5.3. The symbol with the triangle at the base indicates a requirement for a machining allowance, in preference to the old *f* symbol. Another, with the small circle in the base, prohibits machining; hence surfaces must be produced without the removal of material by processes such as cast, forged, hot- or cold-finished, die-cast, sintered- or injection-molded, to name a few. The surface-texture requirement may be shown at A; the machining allowance at B; the process may be indicated above the line at C; the roughness width cutoff (sampling length) at D, and the lay at E. The ANSI symbol provides places for the insertion of numbers to specify a wide variety of texture characteristics, as shown in Table 13.5.2.

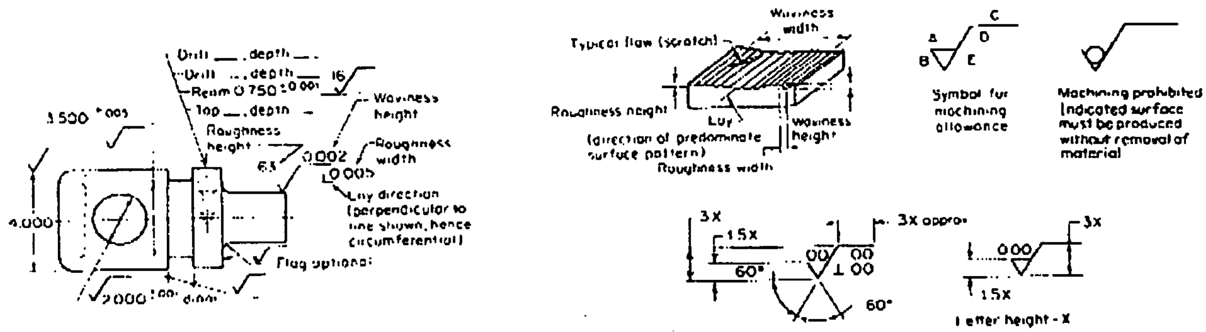


Fig. 13.5.3 Application and use of surface-texture symbols.

Table 13.5.2 Application of Surface-Texture Values to Surface Symbols

(63) 1.6 √	Roughness average rating is placed at the left of the long leg. The specification of only one rating shall indicate the maximum value and any lesser value shall be acceptable.	(63) 1.6 / 3.5 √	Machining is required to produce the surface. The basic amount of stock provided for machining is specified at the left of the short leg of the symbol.
(63) 1.6 / (32) 0.8 √	The specification of maximum value and minimum value roughness average ratings indicates permissible range of value rating.	(63) 1.6 √	Removal of material by machining is prohibited.
(32) 0.8 √ 0.05	Maximum waviness height rating is placed above the horizontal extension. Any lesser rating shall be acceptable.	(32) 0.8 √⊥	Lay designation is indicated by the lay symbol placed at the right of the long leg.
(32) 0.8 √ 0.05−100	Maximum waviness spacing rating is placed above the horizontal extension and to the right of the waviness height rating. Any lesser rating shall be acceptable.	(32) 0.8 √ 2.5 (0.100)	Roughness sampling length or cutoff rating is placed below the horizontal extension. When no value is shown, 0.80 mm is assumed.
		(32) 0.8 √⊥0.5	Where required, maximum roughness spacing shall be placed at the right of the lay symbol. Any lesser rating shall be acceptable.

Control of **roughness**, the finely spaced surface-texture irregularities resulting from the manufacturing process or the cutting action of tools or abrasive grains, is the most important function accomplished through the use of these standards, because roughness, in general, has a greater effect on performance than any other surface quality. The roughness-height index value is a number which equals the arithmetical average deviation of the minute surface irregularities from a hypothetical perfect surface, expressed in either millionths of an inch (microinches, μin, 0.000001 in) or in micrometers, μm, if drawing dimensions are in metric, SI units. For control purposes, roughness-height values are taken from Table 13.5.3, with those in boldface given preference.

The term *roughness cutoff*, a characteristic of tracer-point measuring instruments, is used to limit the length of trace within which the asperities of the surface must lie for consideration as roughness. Asperity spacings greater than roughness cutoff are then considered as waviness.

Waviness refers to the secondary irregularities upon which roughness is superimposed, which are of significantly longer wavelength and are usually caused by machine or work deflections, tool or workpiece vibration, heat treatment, or warping. Waviness can be measured by a dial indicator or a profile recording instrument from which roughness has been filtered out. It is rated as maximum peak-to-valley distance and is indicated by the preferred values of Table 13.5.4. For fine waviness control, techniques involving contact-area determination in percent (90, 75, 50 percent preferred) may be required. Waviness control by interferometric methods is also common, where notes, such as "Flat within XX helium light bands," may be used. Dimensions may be determined from the precision length table (see Sec. 1).

Lay refers to the direction of the predominant visible surface-roughness pattern. It can be controlled by use of the approved symbols given in Table 13.5.5, which indicate desired lay direction with respect to the boundary line of the surface upon which the symbol is placed.

Flaws are imperfections in a surface that occur only at infrequent intervals. They are usually caused by nonuniformity of the material, or they result from damage to the surface subsequent to processing, such as scratches, dents, pits, and cracks. Flaws shoud not be considered in surface-texture meaurements, as the standards do not consider or classify them. Acceptance or rejection of parts having flaws is strictly a matter of judgment based upon whether the flaw will compromise the intended function of the part.

To call attention to the fact that surface-texture values are specified on any given drawing, a note and typical symbol may be used as follows:

$\surd$ Surface texture per ANSI B46.1

Values for nondesignated surfaces can be limited by the note

$\surd$ All machined surfaces except as noted.

MEASUREMENT AND PRODUCTION

Tracer-point analyzers provide an effective and rapid means for determining roughness values. Optical straightedge shadow and interference microscopes provide for measurement and comparison. Standard replicas of typical machined surfaces provide less accurate but adequate reference and control of rougher surfaces over 16 μin.

Various production processes can produce surfaces within the ranges shown in Table 13.5.6. For production efficiency, it is best that critical areas requiring surface-texture control be clearly designated on drawings so that proper machining and adequate protection from damage during processing will be ensured.

SURFACE QUALITY VERSUS TOLERANCES

It should be remembered that surface quality and tolerances are distinctly different attributes that are controlled for com-

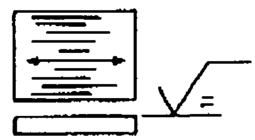
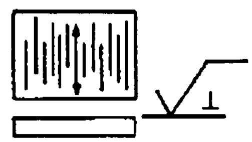
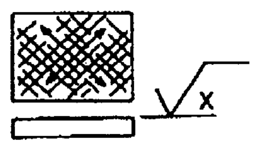
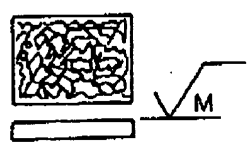
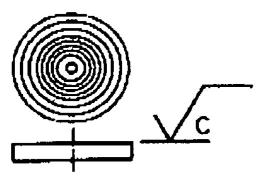
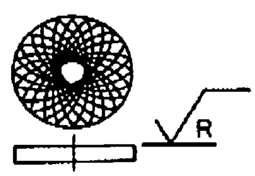
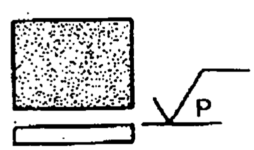
Table 13.5.3 Preferred Series Roughness Average Values (R_a) Micrometres (μm); Microinches (μin)

μm	μin	μm	μin	μm	μin	μm	μin	μm	μin
0.012	0.5	0.125	5	0.50	20	2.00	80	8.0	320
0.025	1	0.15	6	0.63	25	2.50	100	10.0	400
0.050	**2**	**0.20**	**8**	**0.80**	**32**	**3.20**	**125**	**12.5**	**500**
0.075	3	0.25	10	1.00	40	4.0	160	15.0	600
0.10	**4**	0.32	13	1.25	50	5.0	200	20.0	800
		0.40	**16**	**1.60**	**63**	**6.3**	**250**	**25.0**	**1000**

Table 13.5.4 Preferred Series Maximum Waviness Height Values

mm	in	mm	in	mm	in
0.0005	0.00002	0.008	0.0003	0.12	0.005
0.0008	0.00003	0.012	0.0005	0.20	0.008
0.0012	0.00005	0.020	0.0008	0.25	0.010
0.0020	0.00008	0.025	0.001	0.38	0.015
0.0025	0.0001	0.05	0.002	0.50	0.020
0.005	0.0002	0.08	0.003	0.80	0.030

Table 13.5.5 Lay Symbols

Lay symbol	Interpretation	Example showing direction of tool marks
=	Lay parallel to the line representing the surface to which the symbol is applied	
⊥	Lay perpendicular to the line representing the surface to which the symbol is applied	
X	Lay angular in both directions to line representing the surface to which symbol is applied	
M	Lay multidirectional	
C	Lay approximately circular relative to the center of the surface to which the symbol is applied	
R	Lay approximately radial relative to the center of the surface to which the symbol is applied	
P	Pitted, protuberant, porous, or particulate nondirectional lay	

pletely separate purposes. **Tolerances** are established to limit the range of the size of a part at the time of manufacture, as measured with gages, micrometers, or other traditional measuring devices having anvils that make contact with the part. **Surface quality controls**, on the other hand, serve to limit the minute surface irregularities or asperities that are formed by the manufacturing process. These lie under the gage anvils during measurement and **do not use up tolerances**.

Table 13.5.6 Surface-Roughness Ranges of Production Processes